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GB 2262239 A GB 0826198 A WO 92/00120 A1
FR 002657264 A1 US 3910269 A US 3513841 A

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UK CL (Edition L) A5T TCA TCH TCL
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(54) Automatic tensioner for a face mask harness

(57) A respiratory aviation mask comprises a carcass 22 housing an airflow (regulatory and control) valve assembly (55, 56, Figs. 4 and 5) for the inhalation and exhalation phases; a peripheral seal 23 for inter position between the carcass and the face of the (aircrew) mask wearer; and an outer band or sheath 31 incorporating an inflatable region 34 in communication with the ambient/prevailing pressure environment 41 of the carcass through an interconnecting flow passage 35. The sheath incorporates a relatively non-deformable or low deformability outer (marginal) layer 32 and an inner relatively deformable layer 33 for engagement with the outer profile of the carcass, whereby (over-)pressurisation of the carcass - or region defined between the carcass and the mask wearer's face pressurises the sheath whose inner layer is relatively deformed thereby and urged against the carcass, which is thereby pressed against the face of the mask wearer, making the peripheral seal more effective.

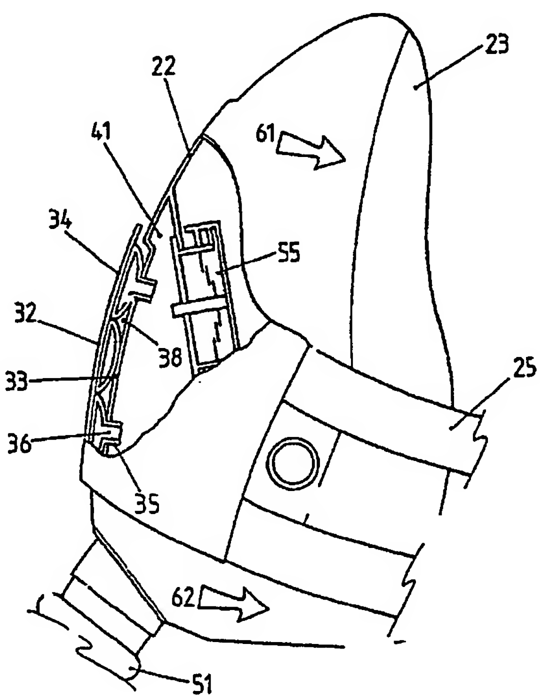

FIG. 6

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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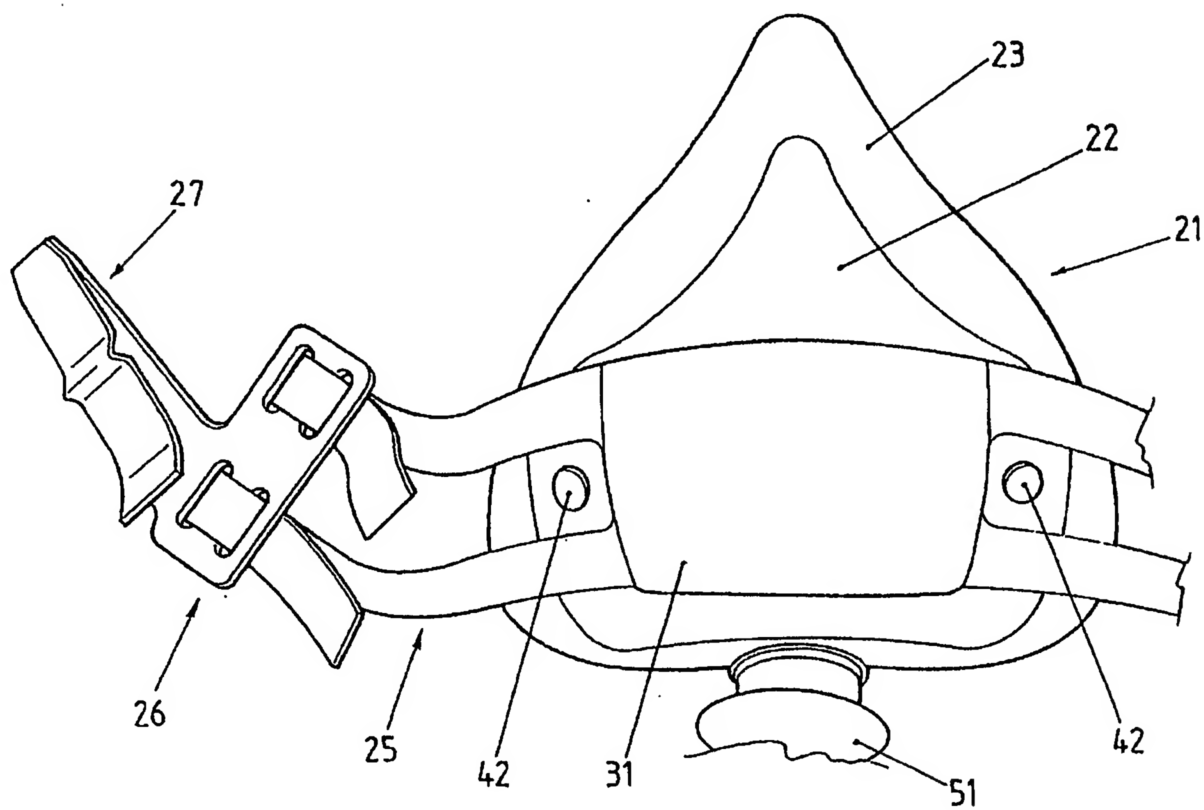

FIG. 1

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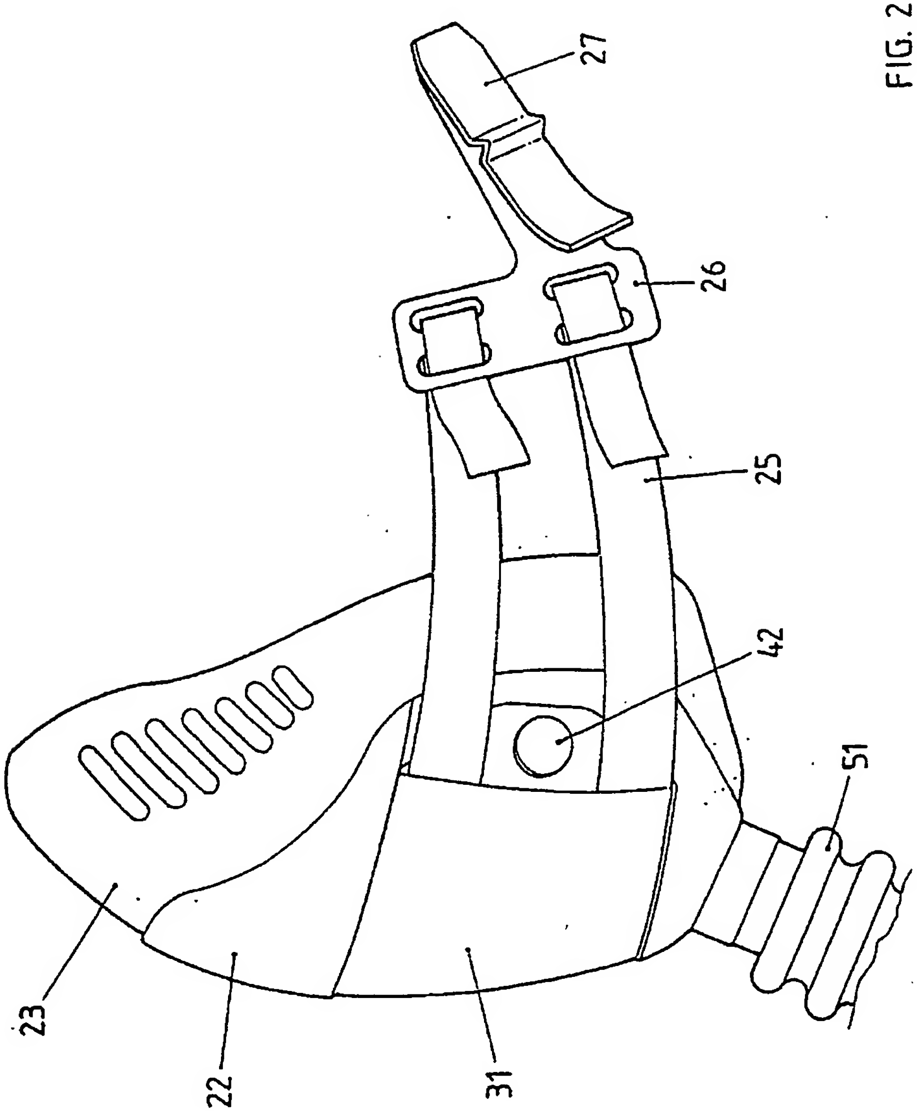

FIG. 2

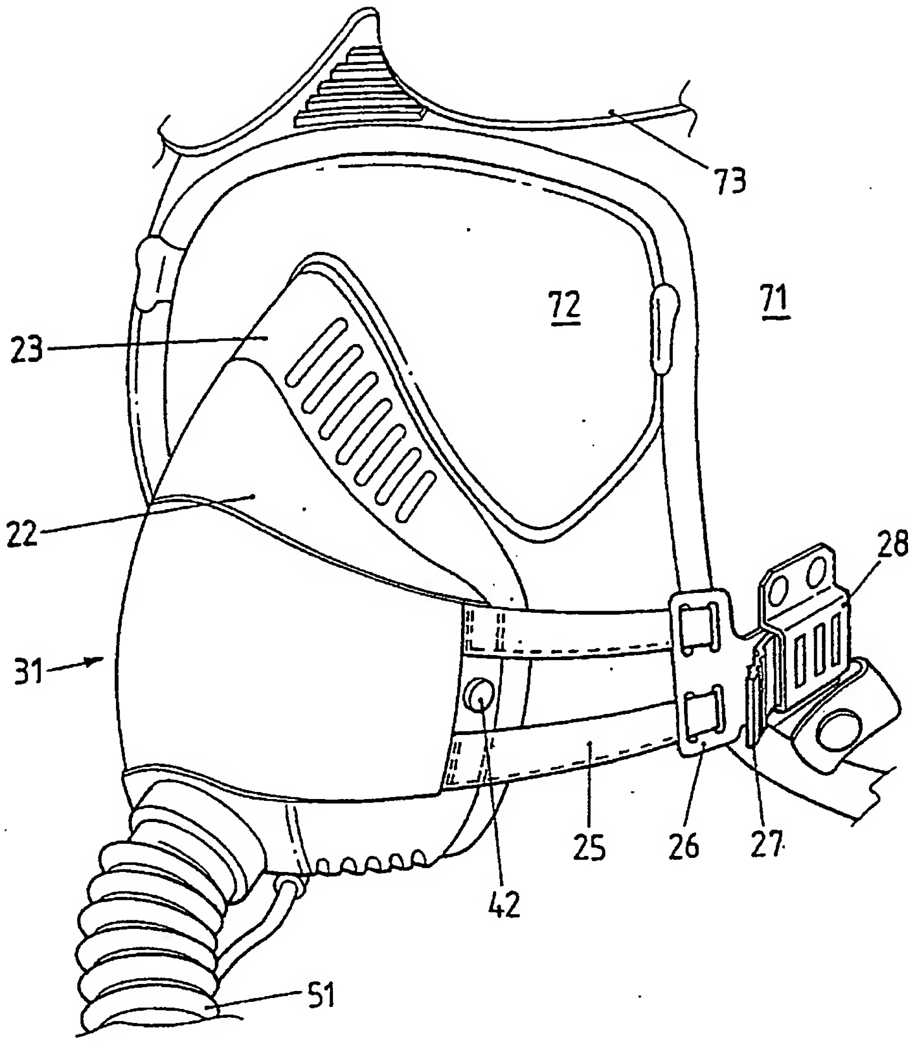

FIG. 3

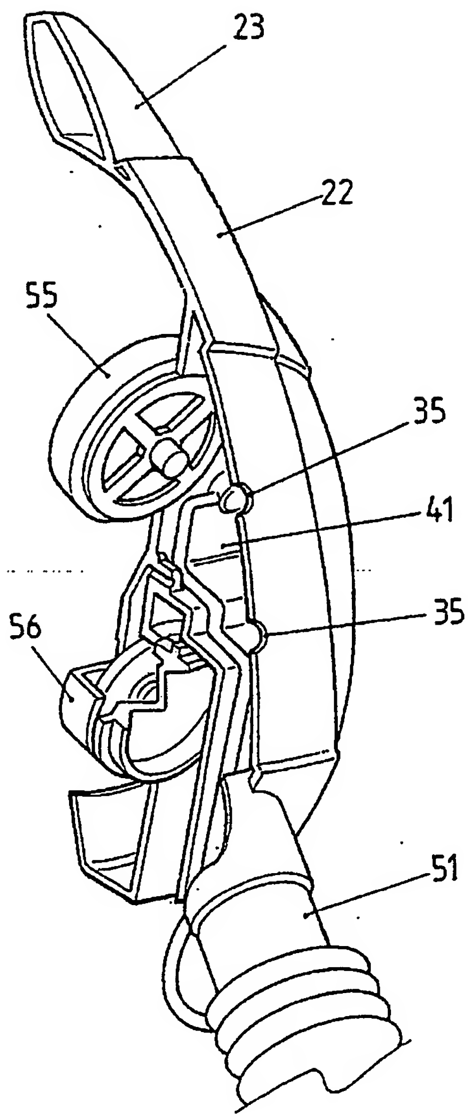

FIG. 4

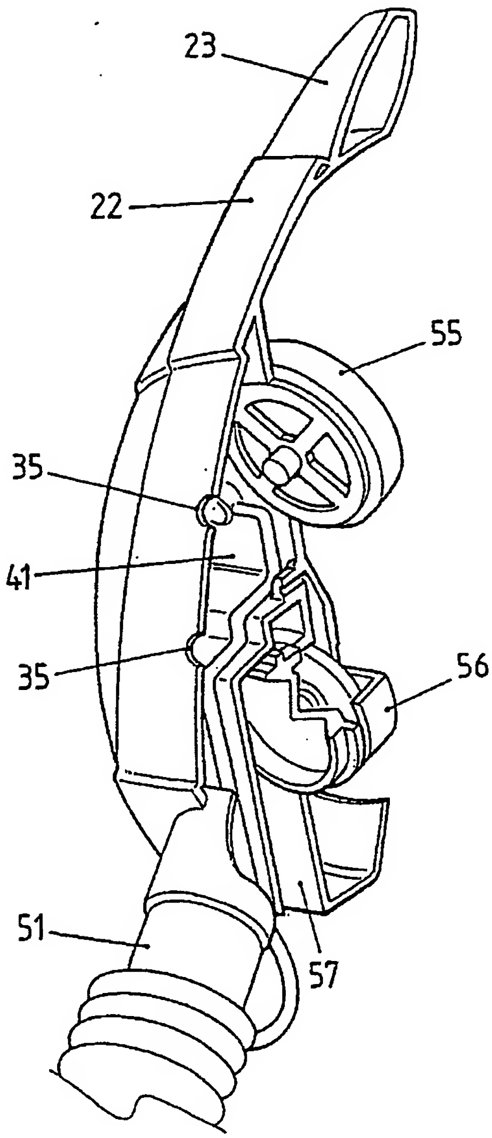

FIG. 5

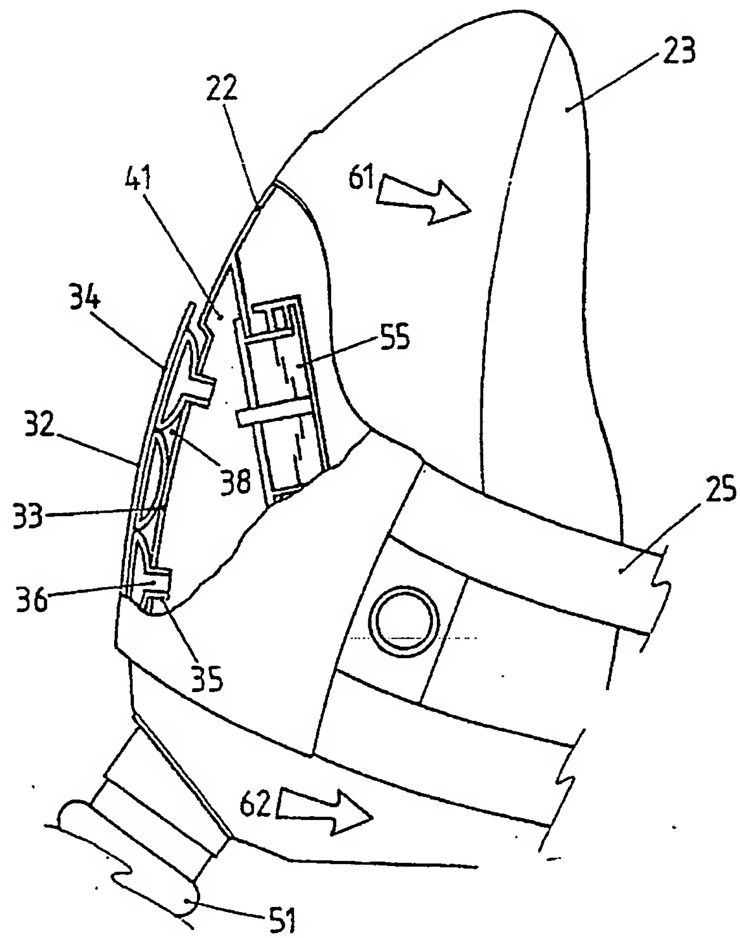

FIG. 6

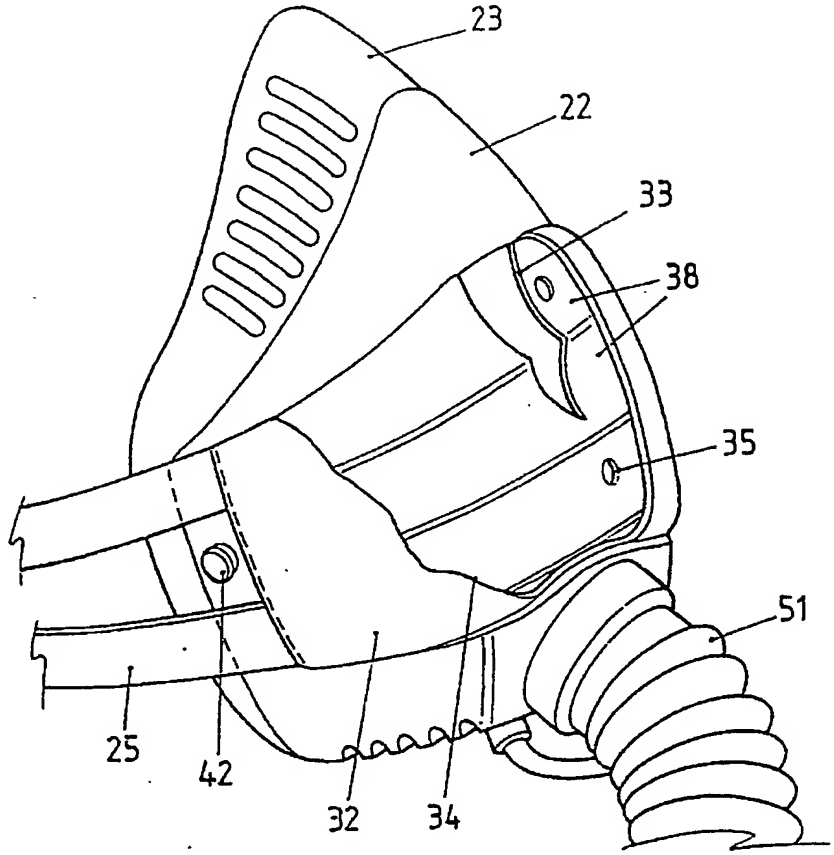

FIG. 7

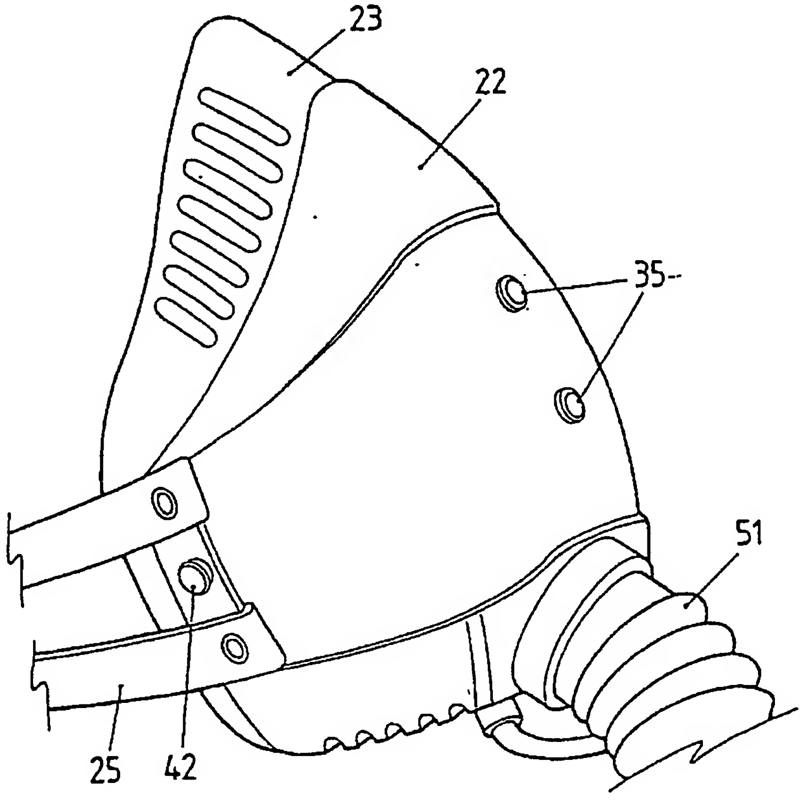

FIG. 8

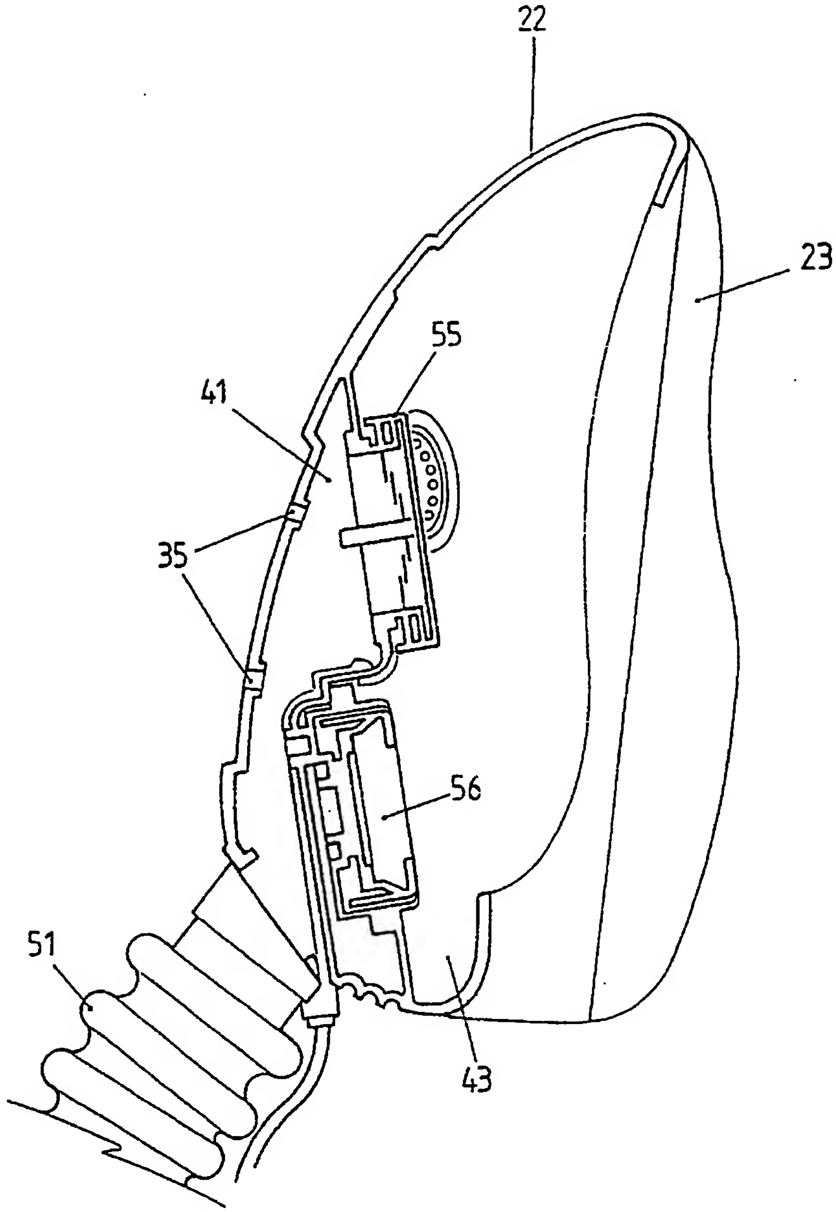

FIG. 9

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Respiratory Mask

This invention relates to masks and is particularly, but not exclusively concerned with a respiratory mask, such as may be applied to or worn by the (breathing) visage or face of an animal or human species.

Respiratory masks for aviation use typically provide a supplementary pressurised air - or selective critical respiratory gas such as oxygen - supply or breathing environment for the mouth and nose orifices and flow tracts.

In aviation medicine it is known that both at high altitude, when the ambient atmosphere 'thins' (ie an attendant low or fall in density and availability of critical respiratory gas components, such as oxygen) and the pressure falls, the 'supply' pressure and air 'content' must be supplemented in order to preserve efficient respiration. In particular, a certain minimum ambient over-pressure must be present for the lungs to perform a satisfactory gas/blood cell interchange.

Unfortunately, the application of higher breathing supply pressures to the wearer's face within a respiratory mask - and in particular a higher pressure differential across the mask in relation to the ambient atmosphere - impresses greater stress demands upon the seal between the mask and the face contours.

In that regard it is known to apply supplementary force to the mask, in order to press it more firmly against the wearer's face, albeit for a temporary period when the high breathing pressures prevail.

For this supplementary mask loading, both user operated mechanical (toggle) devices have been employed for mask harness tensioning, and automatic pressured operated devices, albeit with various practical deficiencies.

As such a respiratory mask must be usable and so compatible with an (aviation/flying) helmet or cap for an individual aircrew member. One aspect of the invention provides an integrated (helmet or cap) face mask and pressure breathing system that is compatible with the hazards encountered in modern airplane environments.

In this environment, critical performance factors are:

(supplementary) pressure breathing - to ensure pilots can operate at their peak or optimum physiological performance under stress, by an appropriate dynamic response of the respiratory oxygen supply system - ie pressure/flow available on demand. Moreover, the sealing and comfort performance of the respiratory face mask have to be combined with a need to make equipment 'user friendly'. Internal respiratory and exhalatory valve performance and breathing 'load' must be constant at all pressure breathing levels. To this end, provision for automated mask tensioning is vital.

high 'g' performance - the oxygen mask requires low physical mass where 'g' loading can cause excessive discomfort and breathing 'hysteresis' (or impaired breathing cycle or rate). Compensated breathing regulatory and control valves and the mask

assemblies must be tolerant of such 'g' loading.

low profile - in order to further reduce 'g' loading and discomfort, and to increase pilot comfort and visibility, the mask may incorporate a multiple (eg two) respiratory control valve system. In a 'low profile' mask, comfort can be further improved by routing the inspiratory supply tube away from the pilot's chest.

low mass - a lightweight compliant structure of the mask enables the various sub-components and assemblies to be fitted with the minimum use of materials and retention devices. Low (inertia) mass can ultimately only be achieved by a coherent approach to the design of the face seal, valves and harness.

The (oxygen) mask may be constructed in a range of different sizes and should incorporate a (reflective) seal and (automatic) mask mounting/support harness tensioning system.

Faceseal

The faceseal and outer casing/housing or exoskeleton may be integrally, moulded - ie as one item - albeit in materials with appropriately different characteristics. This would obviate an additional discrete component with its attendant implications of weight, cost and reliability penalties.

The reflective seal and the automatic tension device must perform over a wide range of pressure breathing levels. An integrated faceseal/exoskeleton moulding offers the prospect of a low mass, low profile compliant assembly affording more reliable sealing and increased pilot comfort.

All inboard components and assemblies may be mounted centrally in the exoskeleton using circumferential seals. Inspiratory, expiratory and microphone assemblies can therefore be mounted at optimum positions to enhance dynamic breathing response and reduce microphone noise.

The mask may be formed from an injection moulded elastomer, with a semi rigid insert to provide location for the inflatable harness and attachment assembly. The compliance of the mask faceseal may promote noise attenuation.

Inspiratory Valve

The valve may consist of a polycarbonate or polyphenyl oxide valve seat and stepped inspiratory petal to give low resistance and stop the valve inverting under high breathing loads.

A flexible shroud may reduce mask noise, wind attenuation and ice ingress. All components should be installable and servicable without special tools.

Expiratory Valve

The use of a two valve system in the mask promotes the dynamic breathing performance whilst achieving a low profile (mask) layout. The 'g' and pressure

compensated expiratory valve may exceed prescribed MOD performance levels. The valve may incorporate a novel seal and valve configuration, thereby reducing the problems of a compensated pressure chamber, which traditionally imposes increased breathing resistance proportional to pressure levels.

The valve may utilise low mass components in order to reduce the effects of 'g' loading and dynamic breathing frequencies.

Microphone capsule

The microphone capsule with an integral pressure diaphragm may be sealed and located in the mask to reduce air noise. Mask noise attenuation may be improved by the use of a semi-rigid faceseal/exoskeleton. The communication line may be hard wired to the mask and interconnect on the helmet assembly. The positioning of the microphone is important to minimise breathing noise. By using a miniature electret, greater flexibility in siting is possible.

Mask harness

The mask harness may retain a twin line connection for the mask and bayonet fixing. As it is critical that the Center of Pressure is maintained, the harness may be retained to the mask using a 'compliant' fixing. Any mask rotation will be accommodated at this point and ensure pressure sealing characteristics of the reflective seal are maintained.

The harness system allows the mask to be used with or without Automatic Mask Tensioning (AMT) - any AMT feed holes being blocked in this latter configuration.

Helmet fixings

The mask harness may be retained on the helmet using a push to fit, pull to release latch. The assembly should have a low profile, but afford large contact area for release and fitting. The latch may provide variable settings to achieve correct fit and pilot comfort. The helmet fixings may be retained on the shell using a novel water activated mask release system (WAMRS).

When the soluble washer dissolves in water, the WAMRS inner rivet is free to exit the shell and release the fixings totally.

Automatic mask tensioning

The mask tensioning device may be integrated within the harness assembly and respond to high pressure breathing levels. An inflatable peripheral sheath sheet, cuff or band is isolated from the mask to ensure that the mask is tensioned symmetrically and retains the pressure seal. The tensioning device responds to supply pressure from the mask hose cavity.

As the auto tension device inflates, it not only applies pressure to the mask faceseal, but also contracts in length - so applying further tension to the mask harness and hence tightening the seal.

Hose

The mask hose may be a traditional convoluted natural rubber design. Its positioning on the mask is critical for head mobility, centre of gravity and freedom from interference with any chest-counter pressure garment (ie 'g'-suit).

The hose length may be defined by expert prescription (eg the BMA) and may be restrained by the inclusion of an interior retention cord. A bayonet connector may be provided for the interface fitting.

Mask Faceseal and Exoskeleton

To reduce weight and provide a single serviceable faceseal, an integrated rigid exoskeleton and moulded silicone faceseal may be provided in multiple (eg two) sizes. A silicone seal may run over the nose and across the chin to achieve the best pressure breathing seal, and the smallest and lightest mask configuration. Provision can be made for an integrated chin cup - albeit at the risk of deteriorating pressure breathing seal and performance.

The (reflective) seal may be bonded to the mask outer casing or exoskeleton, in order to improve consistency in sealing performance. The seal contour and mask profile may reflect anthropometric data on pilot physiogmetry. The mask may have a low profile and all system hardware may locate within the visual horizon created by the sealing edge of the mask facepiece.

The integral facepiece may be made from a polyphenylene oxide injection moulded rigid exoskeleton as an insert moulded into the silicone facepiece. As well as supporting the silicone facepiece the exoskeleton may provide a housing for:

1 a compensated expiratory valve

2 an inspiratory valve and ice shield

3 a microphone capsule

4 a communication line housing

5 a goggle pressure de-mist feed.

Provision may be made within the faceseal to allow the wearer to pinch his/her nose, for active (mouth/nose) pressure compensation.

The inspiratory valve layout allows optimum valve types to be used centrally in the mask assembly, giving maximum user comfort. The mask air supply hose may be located higher than conventional systems in order to give greater freedom of movement and a lower profile. The exoskeleton assembly can be easily stripped for maintenance and in-service replacement. Access to respiratory valves and communication assembly may be achieved by removal of the exoskeleton cover assembly.

Inspiratory Valve

The valve seat and support may be produced form a polycarbonate injection moulding to retain precise control of the seal. It may be retained in the exoskeleton by the exoskeleton cover and sealing affected by use of Viton (Registered Trade Mark of Du Pont De Nemours International SA) seals around the circumference of the valve body. The valve petal and support have been designed to give minimum resistance to high breathing flow rates at all pressure breathing levels.

Ice Shield

The silicone moulding may be configured to give maximum protection from ice build up and to ensure no cold spots occur on the face due to cold or draught. The moulding may be produced in silicone to assist fitting the valve and to reduce the risk of 'oronasal' abrasion.

Expiratory Valve

By adopting an appropriate valve configuration, significant improvements are attainable on expiratory valve performance at high flow, high frequency breathing rates.

The expiratory valve assembly may be configured in the mask exoskeleton so that the compensation line exits directly above the valve compensation chamber.

Microphone Capsule

The microphone capsule may be located in a compartment in the facepiece and sealed using the mask body and a Mylar membrane across the face of the microphone. The communication lead may be directly joined to the microphone capsule and the lead exited through the exoskeleton out of the mask. In order to reduce unnecessary weight and bulk, there need be no mask located plug and socket.

The Mylar membrane protects the microphone from damage by moisture and ambient pressure levels.

A single electret microphone element, with a 'lifted' high frequency response for greater intelligibility may be employed provided the breathing noises do not become too audible, - in which case a more damped characteristic response will prevail.

An electret has several benefits for this application, viz: low mass; low bulk; high sensitivity; very flat response; high MTBF (approximately 5 years).

A small amplifier may be fitted immediately adjacent to the microphone to provide sufficient gain to suit the ICS input. Provision for adjustment may be provided here, if required.

To reduce mass and increase field of view (fov) and reliability, the on/off switch may be eliminated.

Care needs to be taken with the positioning and orientation of the microphone element,

in order to avoid too much interference with the breathing noises and other undesired signals. This is essential in maximising the signal to noise ration and hence articulation index.

Goggle Pressure Feed

A tube may be built into the 'oronasal' moulding of the CB hood, in order to channel pressurised air from the mask to a connection at the goggle retention fixings. When the goggle is removed, a valve in the fitting shuts off the air supply.

Automatic Mask Tensioner

The mask tensioning assembly consists of the inflatable harness, buckle adjustment and helmet interconnects. Initial adjustment of the mask assembly is achieved by altering the straps to give the correct mask attitude. The helmet interconnects then allow incremental adjustment onto the helmet. Automatic (pressure-sensation) mask tensioning is achieved by inflating the strap from a central pressure feed on the inspiratory port.

Inflatable Harness

A single inflatable band or harness is attached across the exterior of the mask, giving compliant location of the facepiece onto the face. At either end, straps are located to provide the correct adjustment for the helmet interconnect.

The harness may consist of a stitched and bonded coated fabric band. On sensing the pressurised air supply, the band inflates pushing the mask onto the face. The outer skin is reinforced and will not expand causing the inner skin to inflate and bear on the mask exoskeleton.

If required, the mask would function without the automatic tension device.

There now follows a description of a particular embodiment of the invention, by way of example only, with reference to the accompanying schematic and diagrammatic drawings, in which:

Figure 1 shows a front (perspective) view of an aviation respiratory mask, incorporating an automatic self-tensioning retaining/mounting strap assembly;

Figure 2 shows a side perspective view of the mask shown in Figure 1;

Figure 3 shows a front perspective view of the respiratory mask of Figures 1 and 2 and in conjunction with an aircrew helmet and face mask;

Figure 4 shows a part-sectioned, part cut-away view of the mask shown in Figures 1 and 2;

Figure 5 shows a part-sectioned, part cut-away view of an alternative construction of the mask shown in Figures 1 and 2 to that shown in Figure 4;

Figure 6 shows a part-sectioned, part cut-away view of the automatic mask strap tensioner assembly of the mask shown in Figures 1 through 5;

Figures 7 and 8 show respectively part cut-away, part-sectioned and whole front perspective views of the automatic mask strap tensioner assembly of Figure 6; and

Figure 9 shows a part cut-away, part-sectioned view of the mask of Figures 1 and 2 with the automatic strap tensioner omitted.

Referring to the drawings, an aviation respiratory face mask 21 comprises a relatively rigid or semi-rigid (ie limited pliability) outer carcass housing 22 with a peripheral face seal 23 for intimate (sealing) (skin) contact with the (variable) face contours of an (aircrew) mask wearer.

The mask 21 is held in place when required by a releasable strap assembly with a (mechanical) operating length adjustment/tensioning buckle 26 and a quick-insertion/release coupling 27 to a helmet (shown in Figure 3).

Between the mask assembly 21 and the mounting strap assembly 25 is an automatic pressure/load sensitive mask (strap) tensioning device 31 - with which the present invention is particularly concerned.

As appreciated more readily from Figures 6 and 7, the automatic mask strap tensioner 31 comprises an outer sheath 32 of relatively rigid, semi-rigid or at least deformation resistant material - essentially impervious to air flow - and an inner layer 33 of relatively flexible or at least more readily deformable material.

Thus, between the outer layer 32 and inner layer 33 is defined a sealed (ie air tight/leakproof) chamber 33 albeit one of variable profile and size according to the ambient internal pressure - or rather to the pressure differential between the chamber and the ambient atmosphere.

The (variable) tensioner chamber 34 connects through passages 35 in the outer housing shell 22 to an inner 'breathing' chamber 41 within the housing and itself communicating with an (unshown) air supply through a corrugated supply hose 51.

Flow regulator/control valve elements 36 may be provided within the tensioner chamber 34 to facilitate pressure transmission from the mask chamber 41.

Moreover the tension 'cuff' may incorporate a series of compartments or cells 38, each individually pressurised and providing complementary/co-operative tensioning 'bands' around the outer housing 22.

The mask wearer gains access to this air supply through an inhalation or inspiration valve 55 and breathes out through an exhalation valve 56 to the ambient atmosphere.

In order to avoid internal canopy misting or even icing, this discharge is optionally through some form of baffle or moisture condenser (unshown) - thus obviating the discharge of moist exhaled air directly upon an aircraft canopy.

Once pressurised, the tensioner (cuff) chamber 34 distends overall, but the outer layer 32 resists (undue) deformation, whereas the resiliently deformable/flexible inner layer 35 can and does distend - but, with the mask secured in place (relative to the wearer's head), this can only be accommodated by movement of the housing 22 away from the outer sheath 32, thus urging the mask shell 22 and the peripheral face seal 23 towards the wearer's face and thus into closer (sealing) conformity therewith.

Referring to Figure 5, in which the automatic tensioner cuff or band 31 is omitted for clarity of illustration, the relative dispositions of the inner breathing chamber 41, (air or selective/oxygen enriched gas admixture) supply pipe 51, inspiratory (input/feed) regulator valve 55, exhalation valve 56 and communicating (feed) passages 35 for the cuff tensioner chamber are depicted more clearly - as is the 'deflected' egress passage 57 for air exhaled through the exhalation (output/exhaust) valve 56.

This layout reflects compatibility with a nose inhalation/mouth exhalation breathing regime.

When operative (ie pressurised), the cuff tensioner 31 thus applies its (sealing) bias to the peripheral face seal 23 evenly over the face region around the nose (bridge)/mouth (cheek) interface.

The cuff tensioner 31 is operative primarily to deal with extreme mouth/face sealing conditions - ie when the automatically regulated (eg 'on demand') air/oxygen enriched air supply is applied at high pressures to compensate for, say, high altitude, high 'g' stress (manoeuvring) conditions - whereupon the mask might otherwise tend to stretch away from the face against the restraining harness 25, causing (seal) leakage between the peripheral seal 23 and the mask wearer's face contours, which might in any event be contorted by the high 'g' loading.

As indicated in Figures 1 to 3, the automatic mask strap tensioner cuff is coupled to the mask (shell) 22 proper by demountable connections 42 on each side of the mask 21.

Figure 3 shows the mask 21 and automatic (strap) tensioner 31 **in situ** on a wearer's face, and in conjunction with a helmet 71, goggles, 72 and, (pivoted) helmet visor 73. The mask mounting strap assembly 25 relies upon the helmet as a mounting reaction point - for which purpose a (female) coupling/connector latch receptacle 28 is provided for the (quick release) male strap coupling 27 on each side of the helmet 71.

The material for the (peripheral) face seal 23 is a compromise between compliability with irregular and mobile face contours and (localised) stiffness to avoid seal disrupting distortion.

It is the helmet 71 which provides the reaction to the mask tension applied through the harness 25 - whether the initial (mechanical) adjustment/setting or the supplementary pressure-driven cuff distortion tension and distension.

The valve elements 36 in the cuff supply may have a one-way function to preserve the cuff chamber 34 internal pressure and thus the automatic (supplementary) tension. As depicted in Figure 9, provided the mask seal 23 is effective against the (unshown)

face contours, the breathing pressure applied to the internal mask chamber 41 from the feed tube 51 is available, through the inspiratory valve 55, to the nose/mouth of the mask wearer in a breathing 'air interchange' environment 43 adjacent the wearer's face.

The supply chamber 41 is thus a modest (semi-isolated) reservoir - which is tapped by the tensioner cuff to apply (progressive) tensioning at and above a prescribed over-pressure - without undermining the respiratory provision through the inspiratory valve 55.

The (face) breathing chamber 43 is a more natural mixed breathing environment, periodically sustained by the reservoir 41 by on demand triggering of the inspiratory valve 55, but allowing some mixture with locally exhaled air, which is nevertheless encouraged directly away through the exit duct 57 (see Figure 5).

Overall, it should be appreciated that, if a high demand pressure arises or is applied to meet the physiological dictates of a tight condition or manoeuvre and which might otherwise explore a seal deficiency undermining the provision and sustaining of that (temporary) pressure, then (supplementary) seal (force) enhanced is applied Automatically through the attendant pressurisation of the cuff tension and over-tensioning of the mask harness 25.

Claims

1 A respiratory mask comprising an integrated (deformation resistant) outer shell or 'exoskeleton' and a resiliently deformable face seal (eg of silicone), to provide a pressurised, supplementary/reinforced/assisted (controlled) breathing/respiratory environment for a wearer; the mask incorporating

a peripheral (automatic) self-tensioning, mounting/fastening, strap comprising an outer/intermediate sheath or membrane of localised flexible/porous fabric;

receiving or in controlled communication with a pressurised (respiratory) chamber environment internally of the mask profile/contour;

in order to apply, from external of the mask shell, a (variable) differential pressure across the mask against the restraint of a mask harness and thereby bias the mask against the face of the wearer.

2 An automatic tensioner for a respiratory face mask, comprising an inflatable outer, sheath or cuff, integrated with the masking mounting and support harness and configured to fit around the periphery of the mask outer contour and disposable for communication with a respiratory supply chamber incorporated in the mask, whereby the ambient internal mask supply and inhalatory respiratory processes are applied to distend or inflate, and thereby tension and stretch, the harness and apply the mask more firmly and securely to the face of the wearer.

3 An automatic respiratory face mask tensioner, as claimed in Claim 2, incorporating a supplementary mechanical tensioning device, such as a one-way ratchet.

4 An automatic respiratory mask tensioner, substantially as hereinbefore described, with reference to an as shown in the accompanying drawings.

5 A respiratory aviation mask, comprising a (carcass) housing an airflow (regulatory and control) valve assembly

for the inhalation and exhalation phases of respiration or aspiration;

a peripheral seal for inter position between the housing and the visage or face of the (aircrew) mask wearer;

an outer band or sheath incorporating an inflatable region, in communication with the ambient/prevailing pressure environment of the housing

through an interconnecting flow passage;

the sheath incorporating a relatively non-deformable or low deformability outer

(marginal) layer

and an inner relatively deformable layer

for engagement with the outer profile of the housing carcass

whereby (over-)pressurisation of the housing - or region defined between the housing and the mask wearer's face

pressurises the sheath

whose inner layer is relatively deformed thereby

and urged against the housing carcass, which is thereby pressed against the face of the mask wearer,

making the peripheral housing seal more effective.

6 A respiratory mask as claimed in Claims 1, in which the tensioner band incorporates a plurality, of co-operatively disposed individual chambers.

7 A (head/skull) helmet or cap incorporating a respiratory mask and automatic tensioning device as claimed in any of the preceding claims.

Pat[illegible]s Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
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Relevant Technical Fields

(i) UK Cl (Ed.L) A5T (TCA, TCH, TCL)

(ii) Int Cl (Ed.5) A62B 18/08

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Search Examiner
D BUCKLEY

Date of completion of Search
23 DECEMBER 1993

Documents considered relevant following a search in respect of Claims :-
1 TO 7

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
E,X	GB 2262239 A	(SEC. OF STATE) whole document	1,2,3, and 5
X	GB 826198	(FRANKENSTEIN) whole document	1 at least
X	WO 92/00120 A1	(CAM LOCK) see eg paragraph bridging pages 13 and 14	1,2,3 and 5
X	FR 2657264 A1	(ULMER) whole document	1,2,3 and 5
X	US 3910269	(ANSITE et al) see eg lines 43 to 59 of column 4	1,2 and 3
X	US 3513841	(SEELER) see eg line 50 of column 3 to line 31 of column 4	1 at least

Databases:The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).